IMPERIAL

Rapid attribution of heatwave health burden to human-induced climate change

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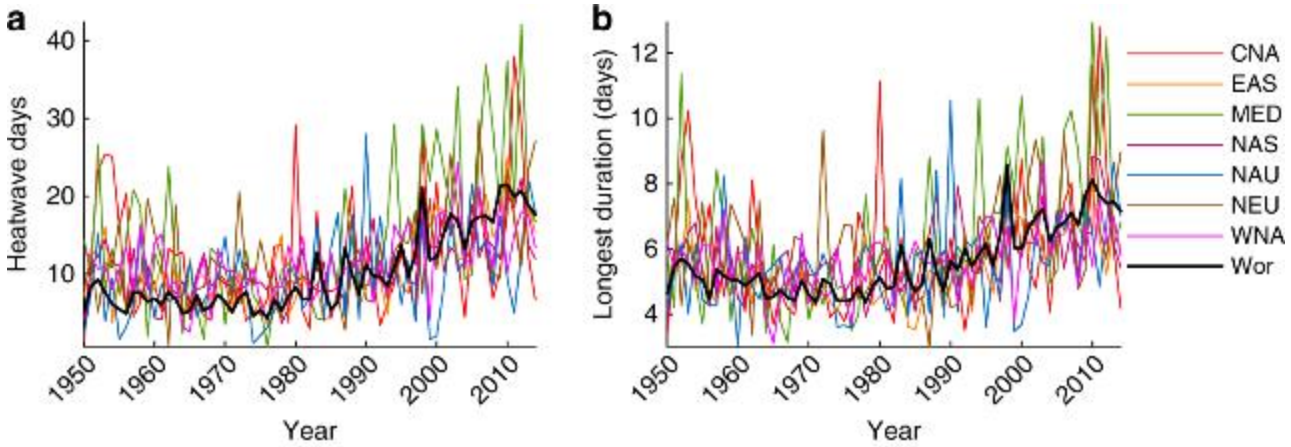
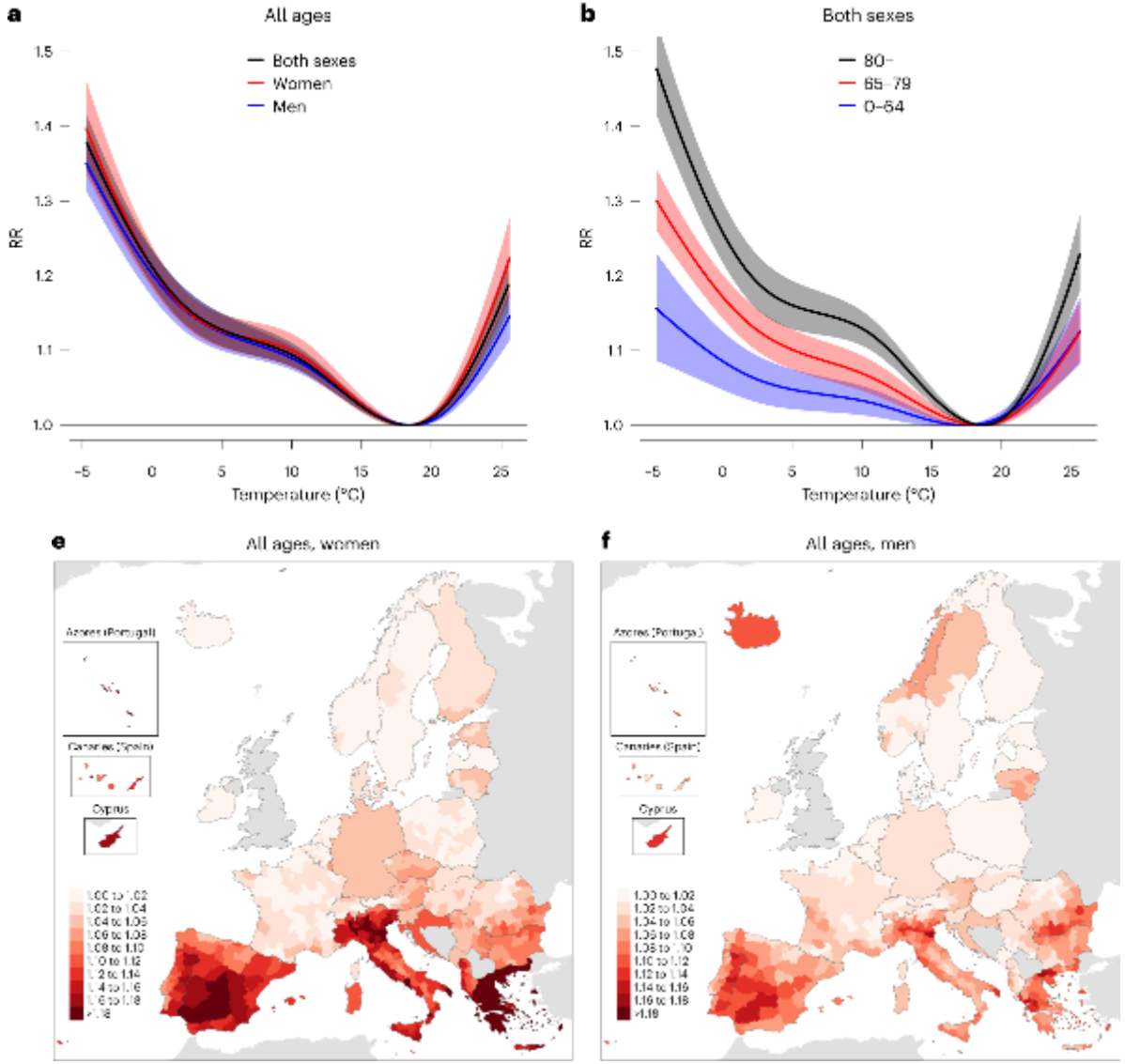
- Heatwaves are becoming more severe and frequent **due to anthropogenic climate change**



https://www.nature.com/articles/s41467-020-16970-7



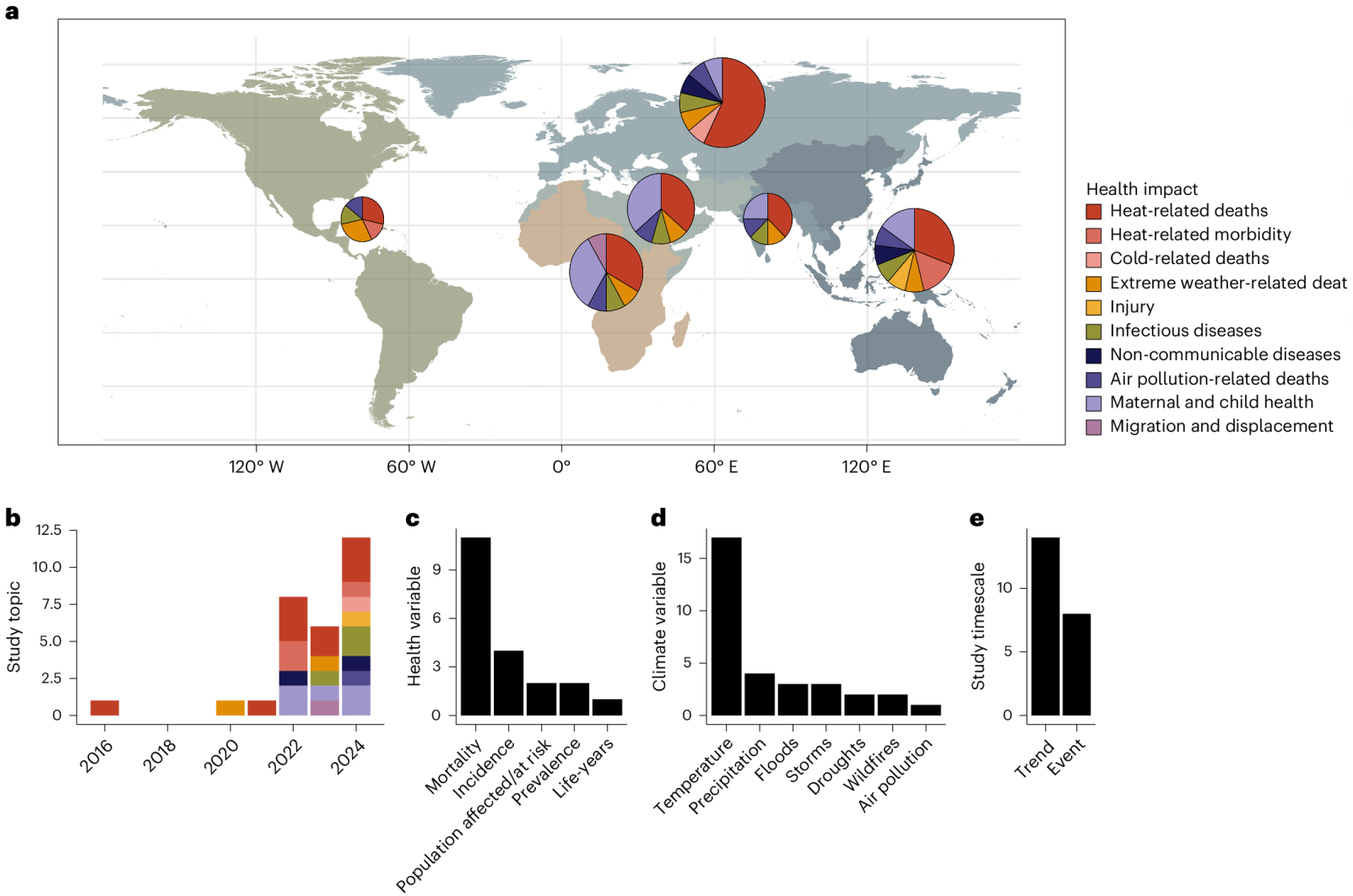
https://www.nature.com/articles/s41591-023-02419-z

Health attribution studies

- Vicedo et al, 2023: 60% of heat related deaths in summer 2022 in Switzerland due to climate change.
- Beck et al, 2024: 56% of heat related deaths in summer 2022 in Europe could be attributed to climate change
- Hundessa et al, 2025: 55% of heatwave-related deaths were attributed to human-induced climate change globally

Climate change kills. Has the world heard the message?

This is just the tip of the iceberg



Houses are damaged in the aftermath of Typhoon Bualoi in Thanh Hoa, Vietnam, Sep 29, 2025. (Photo: AP/VNExpress/Viet Hoang)

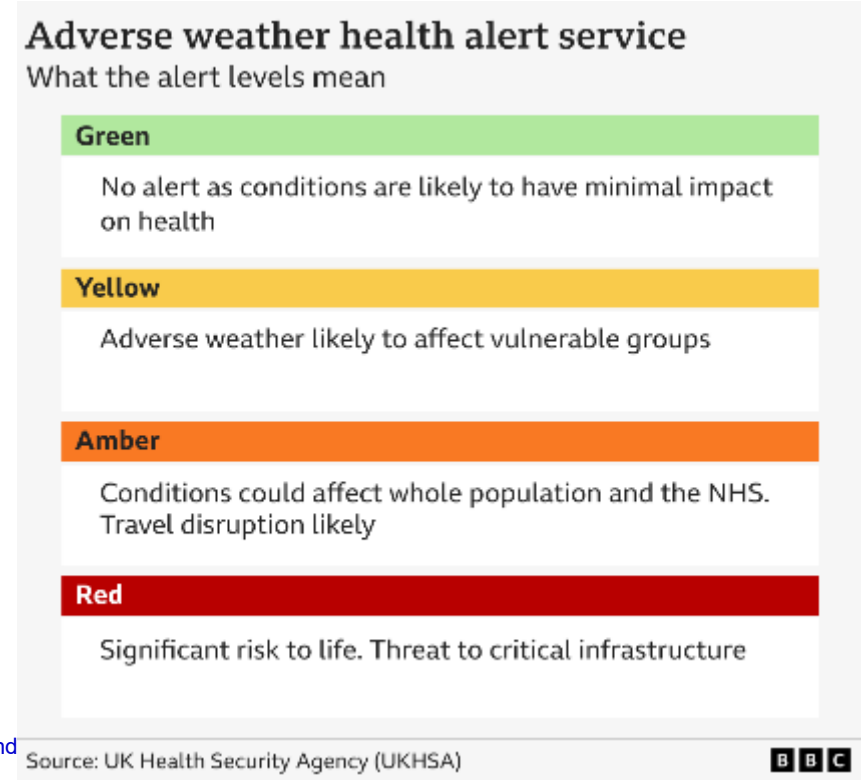
[Health losses attributed to anthropogenic climate change | Nature Climate Change]

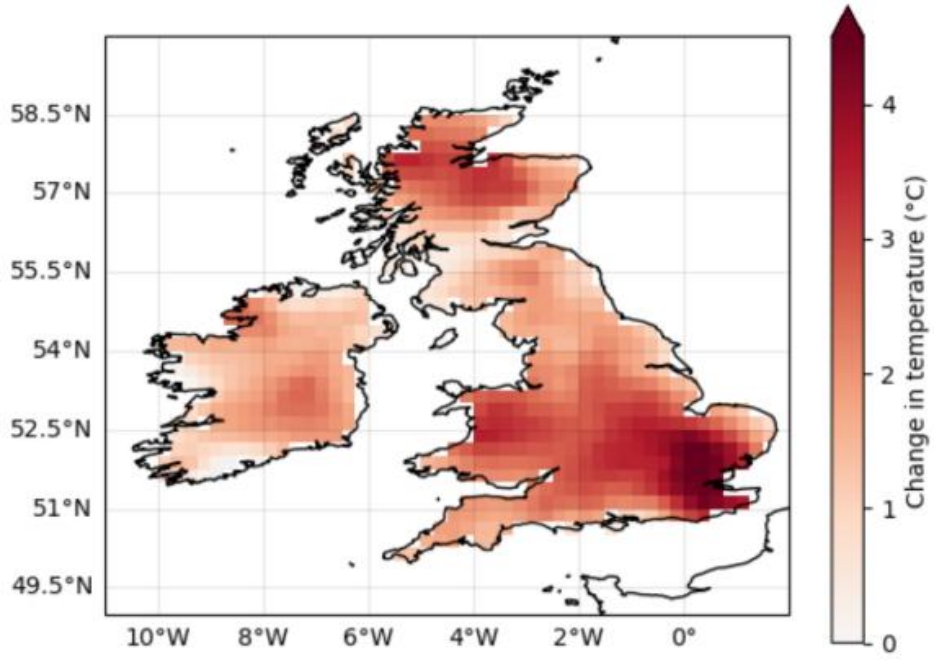
Study 1: Early UK heatwave

UK Heatwave Could Kill 600 People in England & Wales | Health Warning Issued | NEWSDRIFT

Early UK heatwave

- On 19 June, amber heat-health alerts were issued for all areas of England.
- A rapid study by the World Weather Attribution that climate change have made the early heatwaves 2-4oC more intense.
- A lot of media and public interest about the health impacts of the upcoming heatwave.





Estimating the mortality impacts of a heatwave in real time is hard.

Heatwaves are silent killers

- Heat is rarely reported in death certificates as cause of death.
- We need to rely on statistical methods and epidemiological functions.

Observed deaths

- Not available before or during the event.

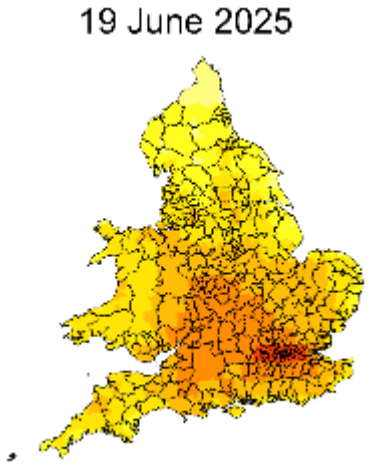
Official reports

- Available for some countries, but months after the event.
- Rely on the model used.

Our approach

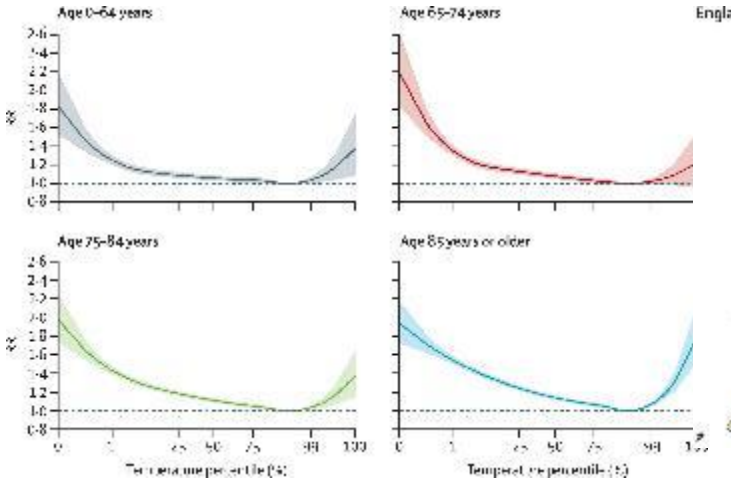
Operational weather forecast (e.g., ECMWF)

- High resolution 15-day temperature forecasts
- Spatiotemporal aggregation of the data



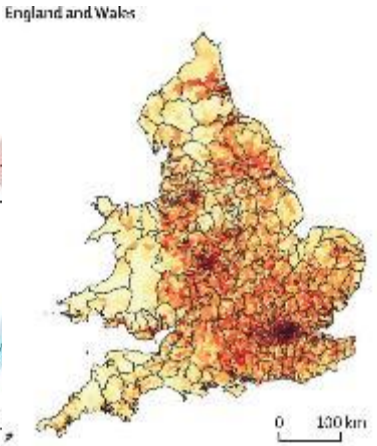
Epidemiological models

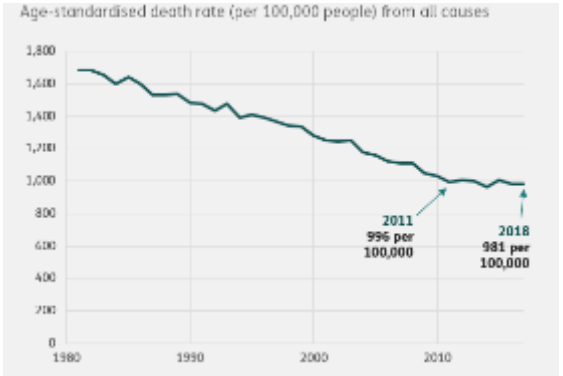
- Previously published temperature mortality curves.
- Age, sex, space



Baseline mortality rates and population

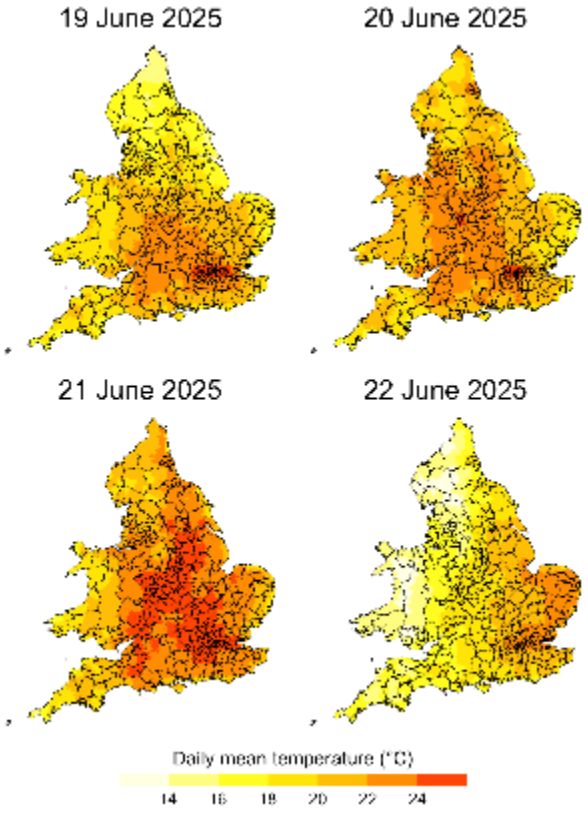
- Retrieve historical mortality rate (deaths2022/population 2020)
- Estimate expected deaths based on this and recent population figures

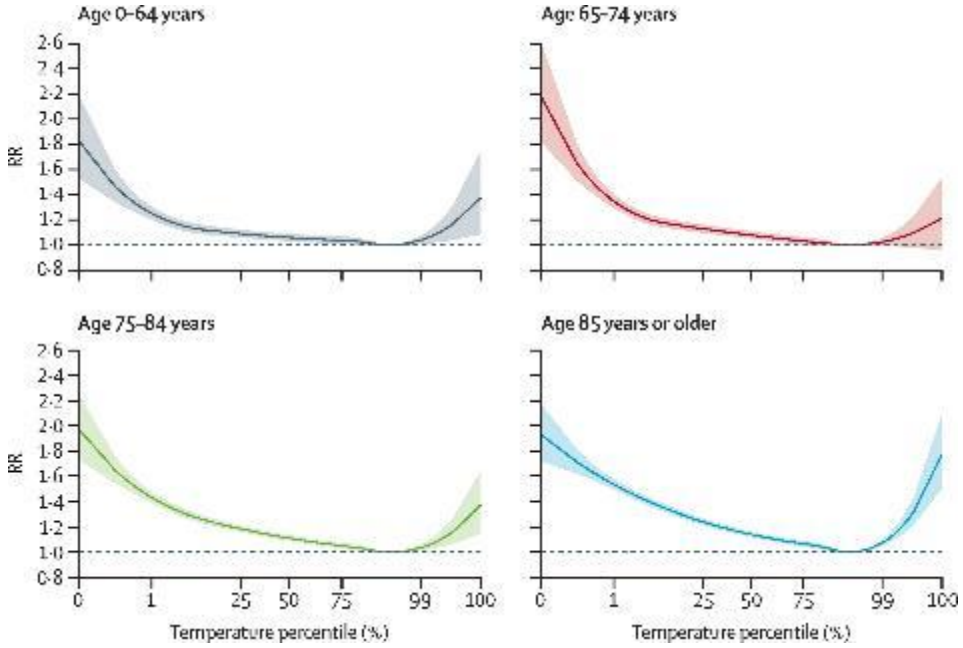


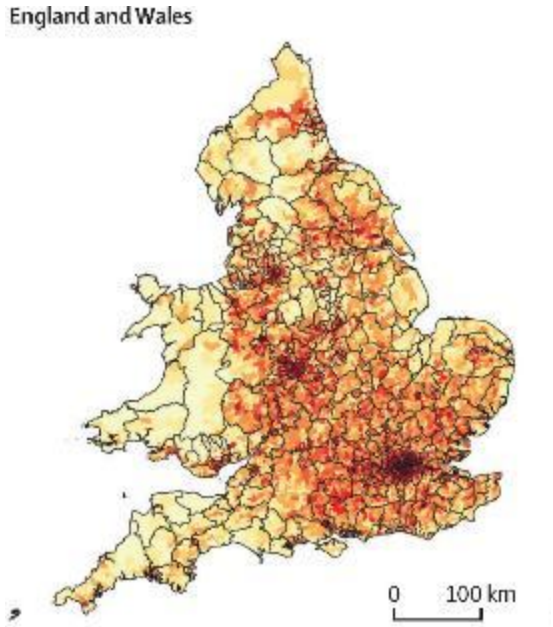


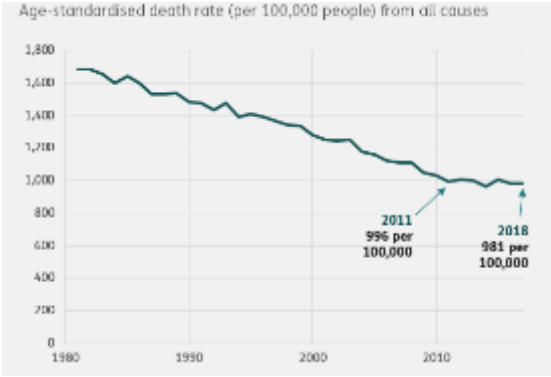
Our approach

- For each **forecasted** temperature we retrieve the **relative risk**.
- From each relative risk we retrieve the **attributable fraction** (RR-1/RR)
- We multiply the **expected deaths** with the attributable fraction to get the **excess due to heat**









Results

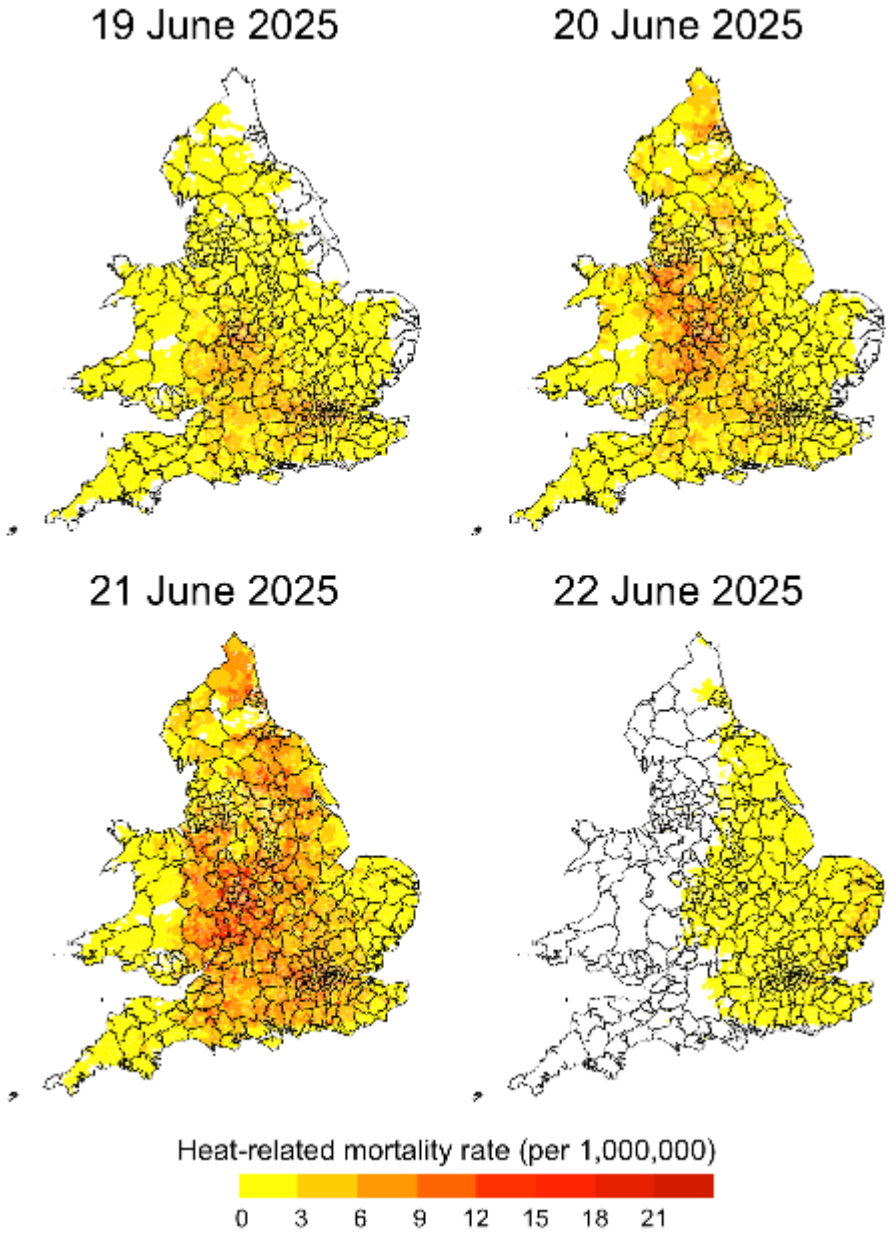
What do we report?

Population, Excess deaths and mortality rate.

Stratification	Population	Excess deaths	Mortality rate
Total	59,719,724	570 (435 to 673)	9.5 (7.3 to 11.3)
Date			
19-Jun-25	59,719,724	114 (92 to 136)	1.9 (1.5 to 2.3)
20-Jun-25	59,719,724	152 (111 to 186)	2.6 (1.9 to 3.1)
21-Jun-25	59,719,724	266 (195 to 318)	4.5 (3.3 to 5.3)
22-Jun-25	59,719,724	37 (29 to 45)	0.6 (0.5 to 0.7)
Age groups			
0-64	48,587,115	82 (25 to 132)	1.7 (0.5 to 2.7)
65-74	5,960,269	49 (-7 to 95)	8.2 (-1.2 to 16.0)
75-84	3,680,770	125 (58 to 185)	34.0 (15.7 to 50.2)
≥85	1,491,570	314 (233 to 384)	210.5 (155.9 to 257.8)

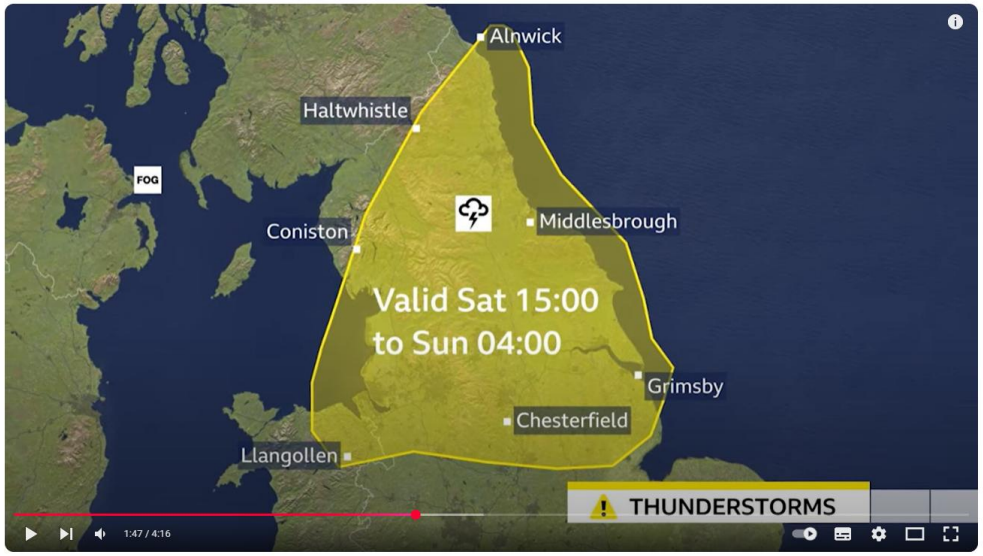
Results
Spatial variation

Stratification	Population	Excess deaths	Mortality rate
Regions			
East Midlands	4,865,583	41 (26 to 54)	8.5 (5.4 to 11.1)
East of England	6,269,161	38 (26 to 49)	6.0 (4.2 to 7.8)
London	9,002,488	129 (99 to 156)	14.3 (10.9 to 17.4)
North East	2,680,763	22 (3 to 37)	8.4 (0.9 to 13.9)
North West	7,367,456	52 (34 to 68)	7.1 (4.6 to 9.2)
South East	9,217,265	81 (52 to 107)	8.8 (5.7 to 11.6)
South West	5,659,143	40 (24 to 54)	7.1 (4.3 to 9.5)
Wales	3,169,586	18 (8 to 26)	5.7 (2.4 to 8.3)
West Midlands	5,961,929	106 (81 to 124)	17.8 (13.6 to 20.9)
Yorkshire and The Humber	5,526,350	41 (26 to 53)	7.5 (4.8 to 9.7)



Outreach

- Story covered by more than **300** media outlets including the Guardian, the Independent, the Mirror, Daily Mail, etc.
- Most read story in the Guardian on Saturday morning
- Interviews/podcasts/radio



UK Heatwave Could Kill 600 People in England & Wales | Health Warning Issued | NEWSDRIFT

Current heatwave 'likely to kill almost 600 people in England and Wales'

Surge in deaths would not be occurring without human-caused global heating, scientists say as analysis published

- **How has climate contributed to these deaths?**

Study 2: Early European heatwave

Early EU heatwave

- Many cities in Europe experienced the first extreme heatwave of the summer in the last week of June and the first days of July 2025.
- Schools in parts of France had to be closed and outdoor working was banned during the hottest parts of the day in Italy.
- Second amber health alerts in UK, severe health warnings, including Paris, Rome, Milan, Sassari, Lisbon and several cities across the Balkans.
- What is the impact of human induced climate change on these events and what is the corresponding health toll?

https://www.theguardian.com/world/2025/jul/01/italy-limits-outdoor-work-as-heatwave-breaks-records-across-europe

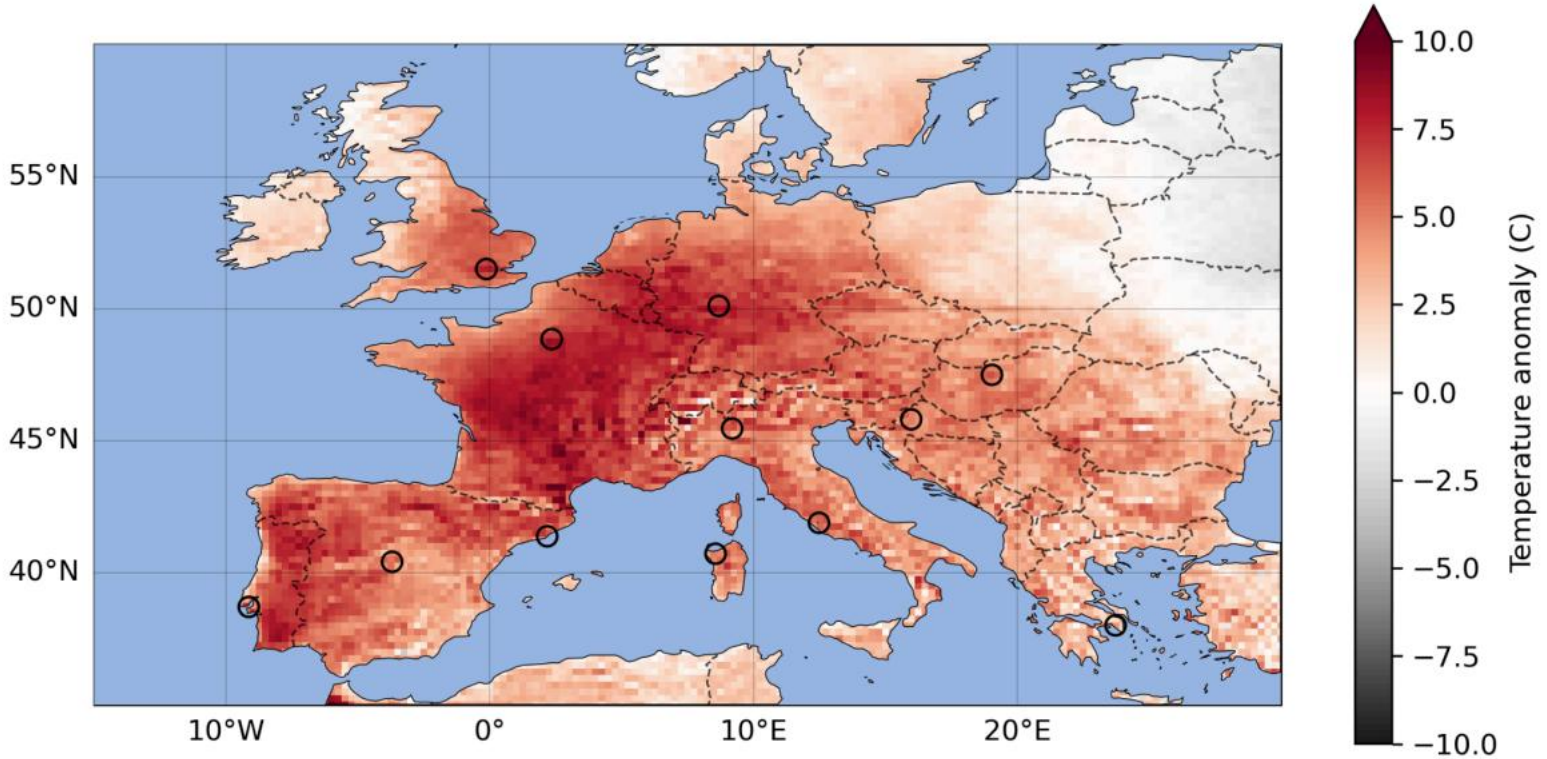
12 Major cities in Europe

Focusing on 12 EU cities:

London, Paris, Frankfurt, Zagreb, Budapest, Athens, Rome, Milan, Sassari, Barcelona, Madrid, Lisbon

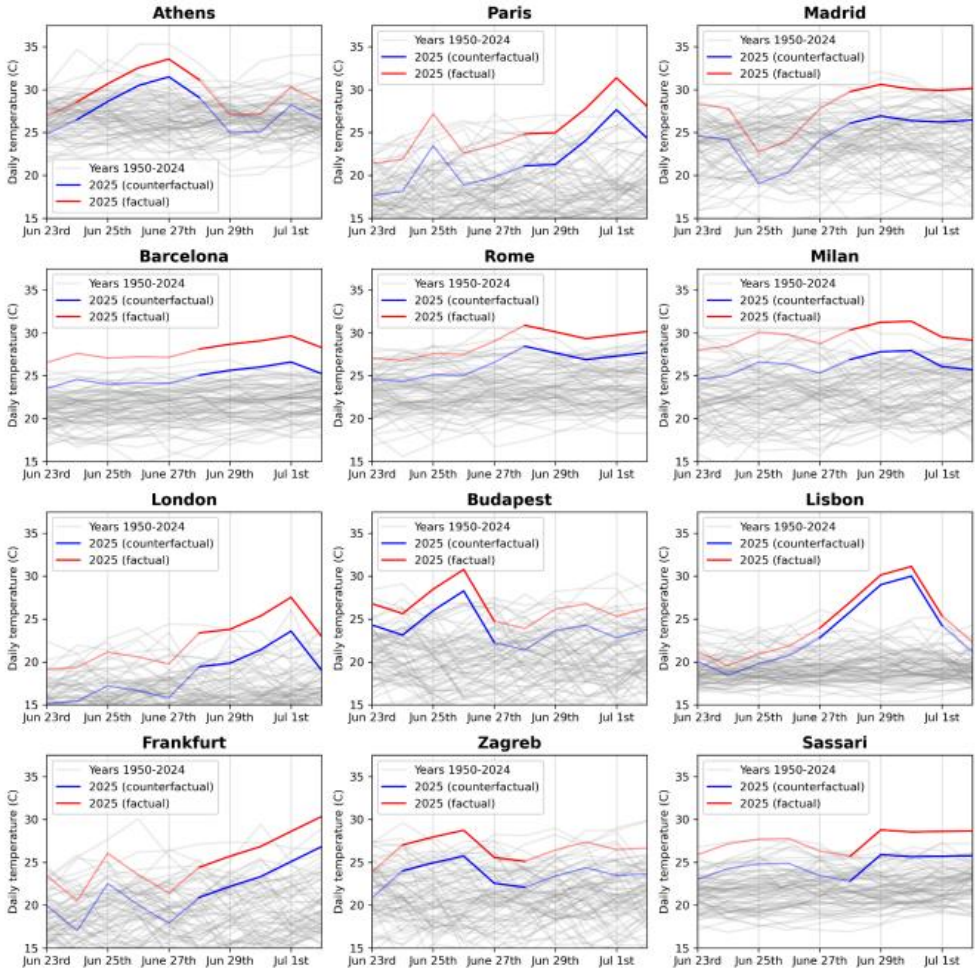
From June 23 to July 2.

- **Objective 1**: Quantify the contribution of climate on the observed events
- **Objective 2**: Quantify the death toll related with climate change
- **Objective 3**: Raise awareness

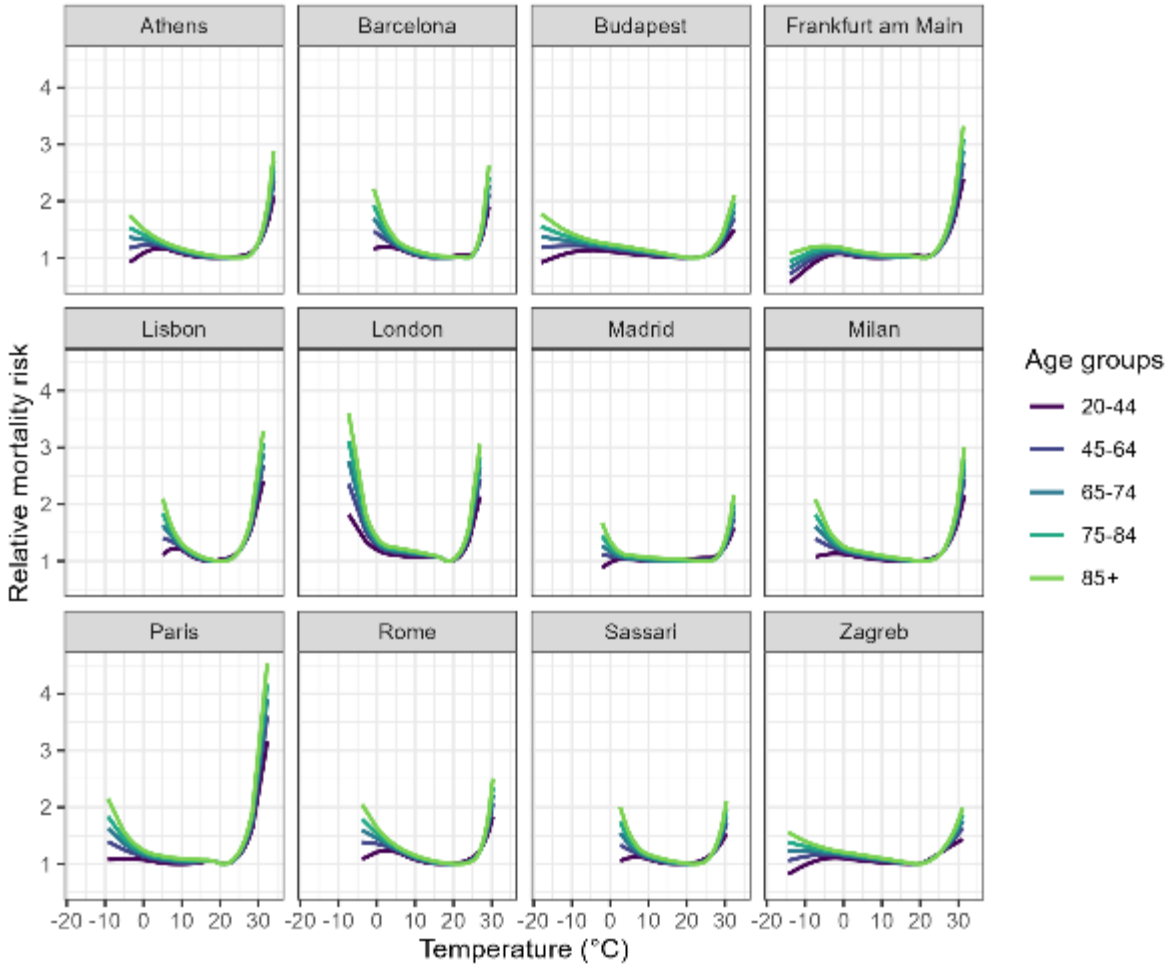


Our approach

Temperature time series (factual and counterfactual)

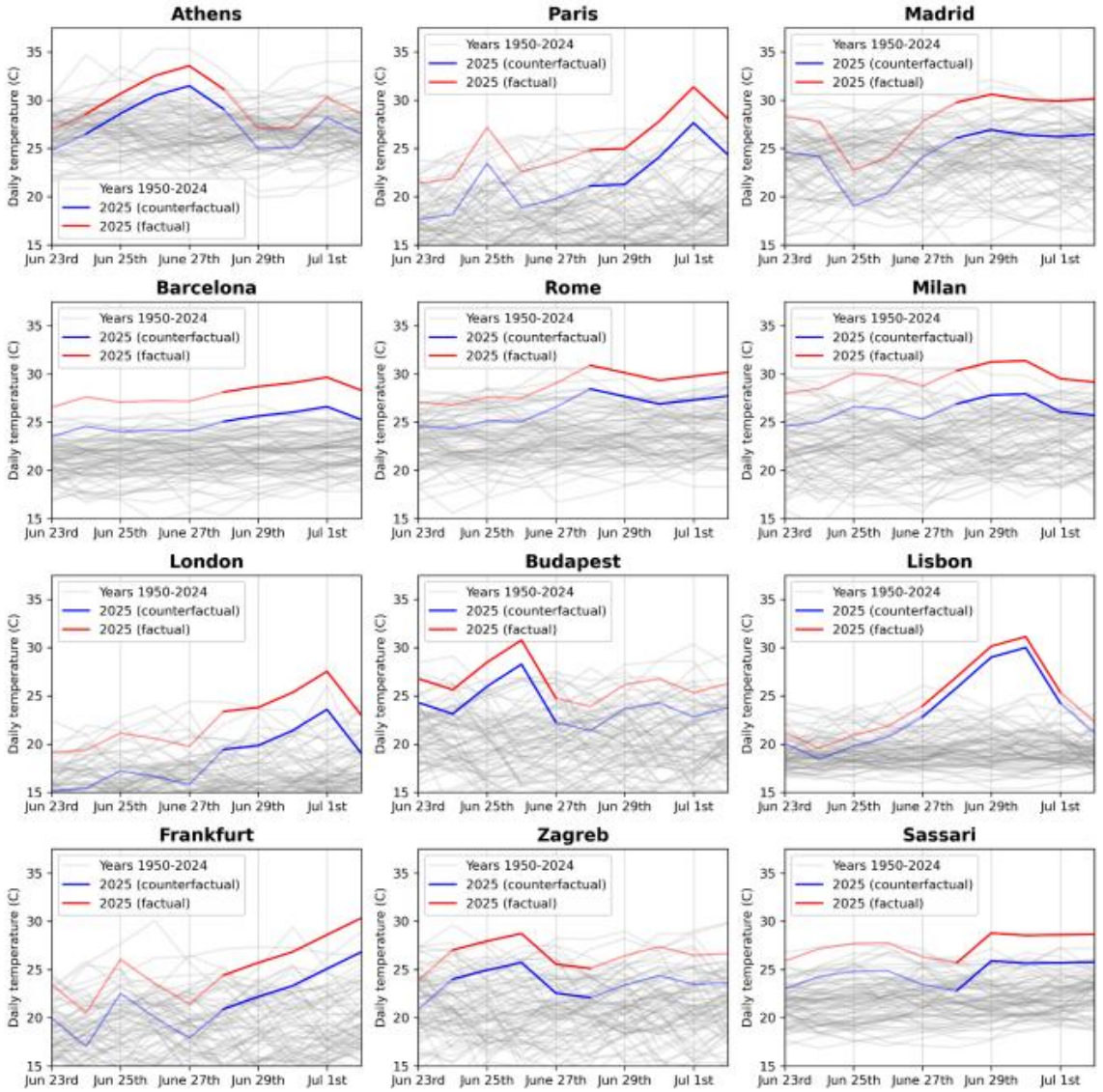


Loss functions based on the literature



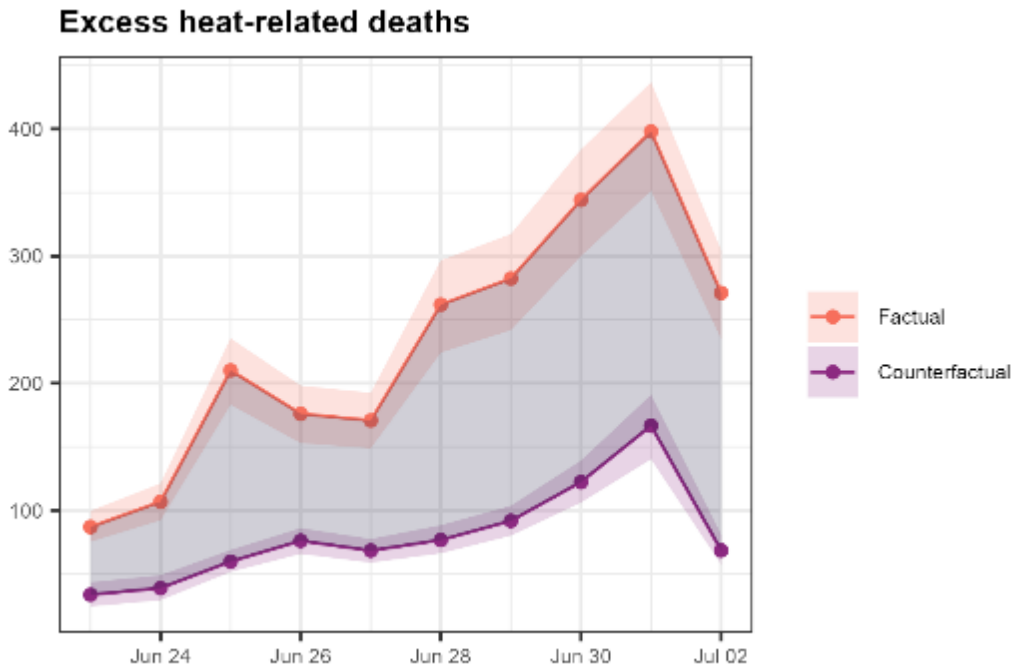
The counterfactuals

City	5-day event (ERA5)		Synthesised change in intensity (°C) (95% C.I.)
	Magnitude (°C)	Return period	
London	24.60	6.23	3.95 (2.59 – 5.43)
Paris	27.42	5.63	3.72 (1.87 – 5.51)
Frankfurt	27.45	2.88	**3.52 (1.34 – 5.55)**
Budapest	28.75	5.91	**2.50 (1.31 – 3.68)**
Zagreb	27.50	1.52	**3.01 (1.65 – 4.46)**
Athens	31.30	1.97	**2.07 (0.52 – 3.64)**
Rome	30.12	3.69	**2.45 (0.64 – 4.28)**
Milan	30.32	1.74	3.44 (-0.89 – 7.78)
Sassari	28.65	5.64	**2.89 (1.51 – 4.31)**
Barcelona	29.04	19.24	**3.05 (1.13 – 4.97)**
Madrid	30.16	1.18	3.68 (2.88 – 4.29)
Lisbon	27.52	148.47	1.13 (-0.69 – 2.80)



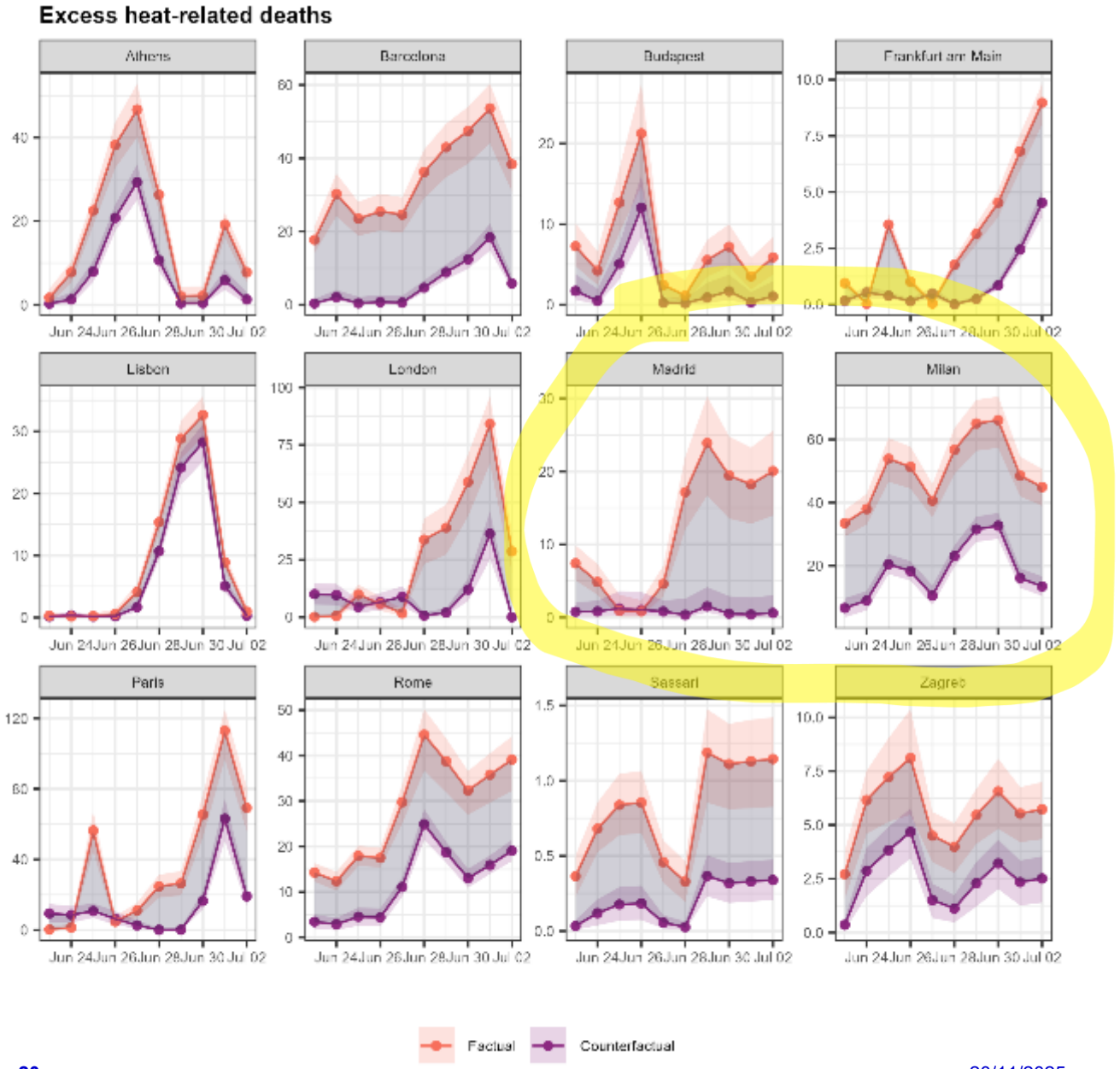
The mortality toll

Age group	Population	Heat-related excess			Proportion of excess deaths due to climate change
		Excess deaths	Rate per 1 million population	Attributable to climate change	
Total	30,046,302	2305 (2022, 2576)	77 (67, 86)	1504 (1262, 1709)	0.65 (0.61, 0.68)
20-44	13,388,164	43 (33, 53)	3 (2, 4)	25 (16, 32)	0.57 (0.48, 0.64)
45-64	10,075,676	253 (211, 292)	25 (21, 29)	158 (125, 187)	0.63 (0.57, 0.67)
65-74	3,420,447	331 (287, 373)	97 (84, 109)	212 (175, 244)	0.64 (0.60, 0.67)
75-84	2,212,630	652 (572, 725)	295 (259, 328)	424 (356, 481)	0.65 (0.61, 0.68)
85+	949,385	1028 (902, 1141)	1082 (950, 1202)	684 (581, 769)	0.67 (0.63, 0.69)

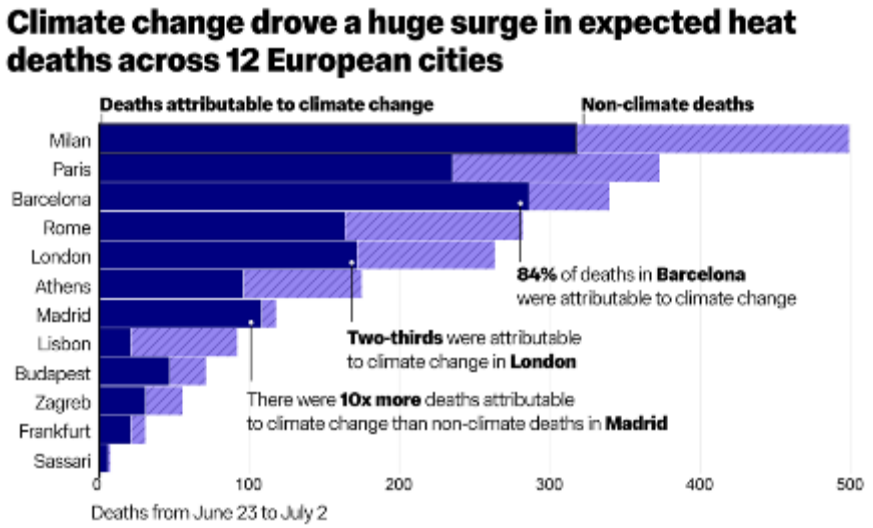


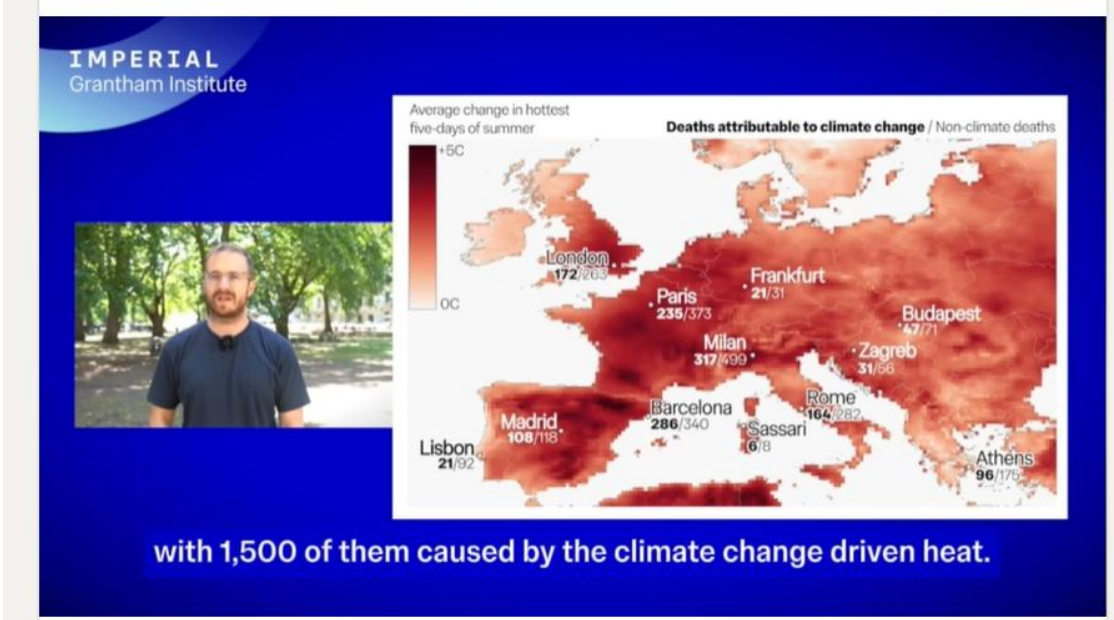
The mortality toll

City	Population	Heat-related excess				Proportion of excess deaths due to climate change
		Excess deaths	Rate per 1 million population	Standardised rate per 1 million population	Attributable to climate change	
Paris	6,869,559	373 (301, 438)	54 (44, 64)	61 (50, 72)	235 (189, 278)	0.63 (0.59, 0.66)
London	5,894,656	263 (192, 322)	45 (33, 55)	65 (48, 80)	171 (116, 216)	0.65 (0.58, 0.71)
Milan	3,144,159	499 (434, 558)	159 (138, 177)	134 (116, 150)	317 (258, 370)	0.64 (0.57, 0.69)
Madrid	2,871,466	118 (85, 150)	41 (30, 52)	41 (30, 53)	108 (73, 139)	0.92 (0.82, 0.95)
Barcelona	2,711,735	340 (276, 396)	125 (102, 146)	117 (95, 136)	286 (226, 331)	0.84 (0.78, 0.86)
Athens	2,269,492	175 (150, 198)	77 (66, 87)	75 (64, 85)	96 (83, 109)	0.55 (0.50, 0.59)
Rome	2,158,892	282 (241, 316)	131 (112, 146)	117 (100, 131)	164 (128, 192)	0.58 (0.51, 0.64)
Lisbon	1,425,616	92 (83, 101)	65 (58, 71)	61 (55, 67)	21 (19, 23)	0.23 (0.22, 0.23)
Budapest	1,414,149	71 (49, 97)	50 (34, 68)	53 (36, 72)	47 (33, 63)	0.67 (0.56, 0.71)
Zagreb	630,723	56 (42, 68)	89 (67, 108)	98 (74, 119)	31 (20, 41)	0.56 (0.42, 0.70)
Frankfurt am Main	552,396	31 (27, 34)	56 (49, 62)	67 (58, 75)	21 (18, 23)	0.68 (0.66, 0.69)
Sassari	103,459	8 (6, 10)	78 (60, 97)	69 (53, 85)	6 (4, 8)	0.76 (0.64, 0.86)



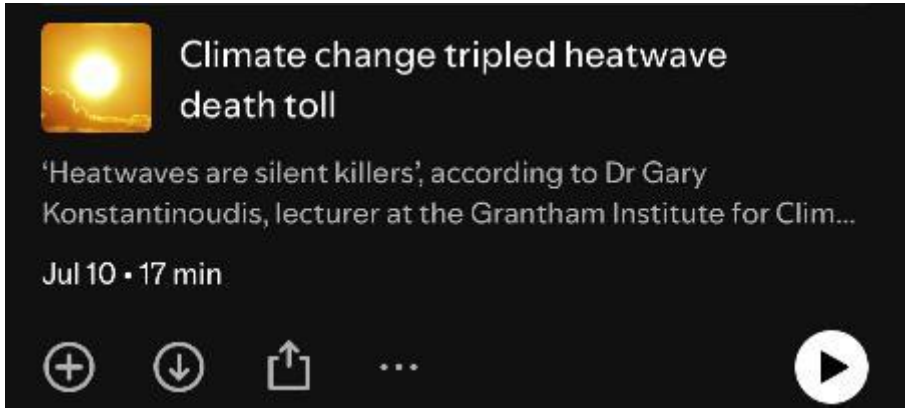
Outreach



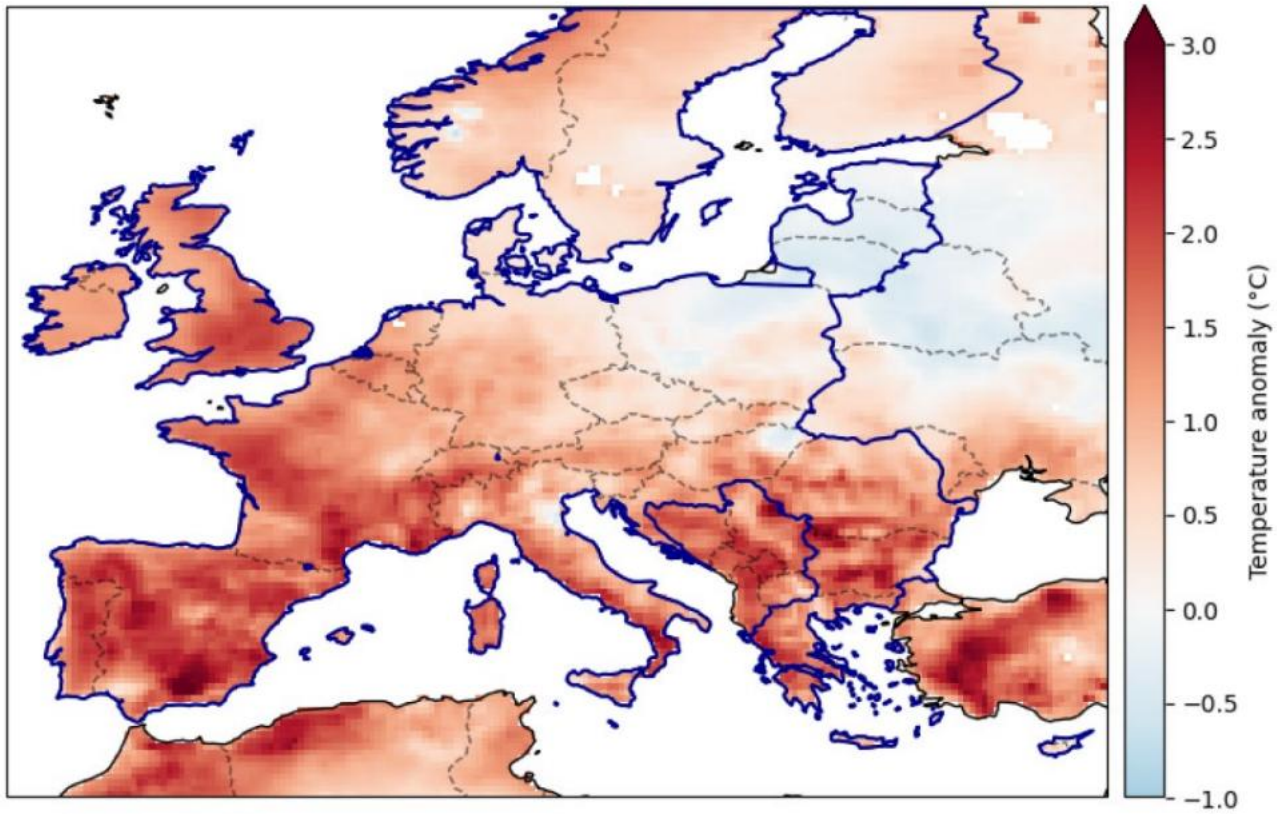


Research Suggests Climate Change Added Excess Deaths in European Heat Wave

The rapid analysis by World Weather Attribution calculated that climate change might have tripled the death toll from the event.



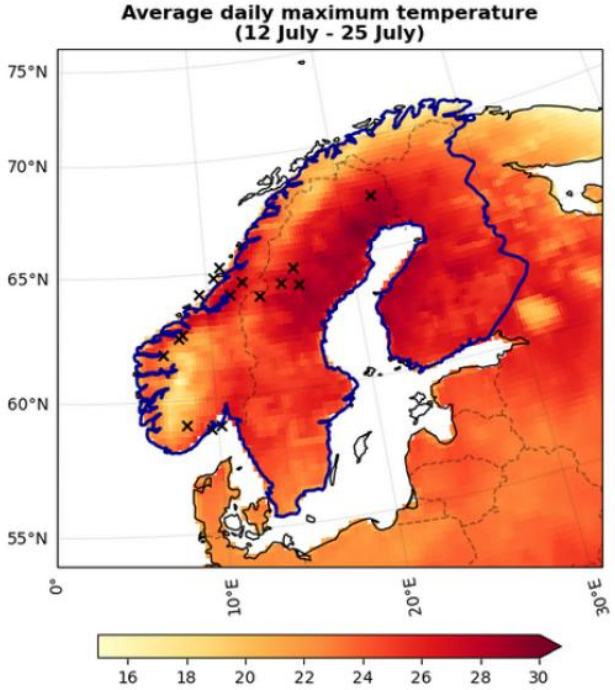
Study 3: EU aftermath of Summer 2025



EU summer 2025

- Summer 2025 has been “roasting hot” across Europe, with back-to-back heatwaves affecting both humans and the economy
- Temperatures rose above 40°C, and up to 46°C in Spain and Portugal
- Fennoscandia also experienced an exceptionally persistent heatwave in July
- Southeast Europe faced heatwaves in July and a national record temperature of 50.5°C was recorded in Türkiye

https://www.nature.com/articles/d41586-025-02553-3

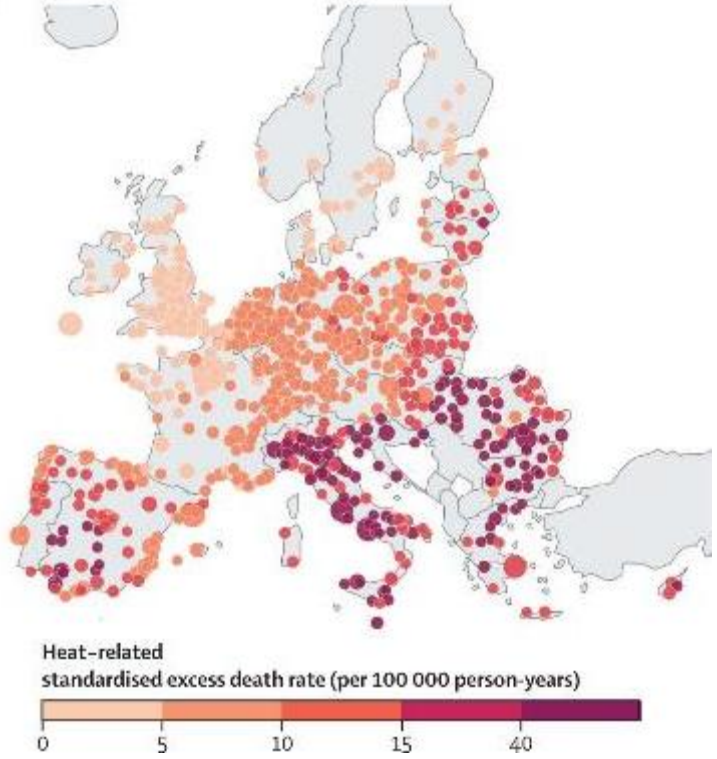


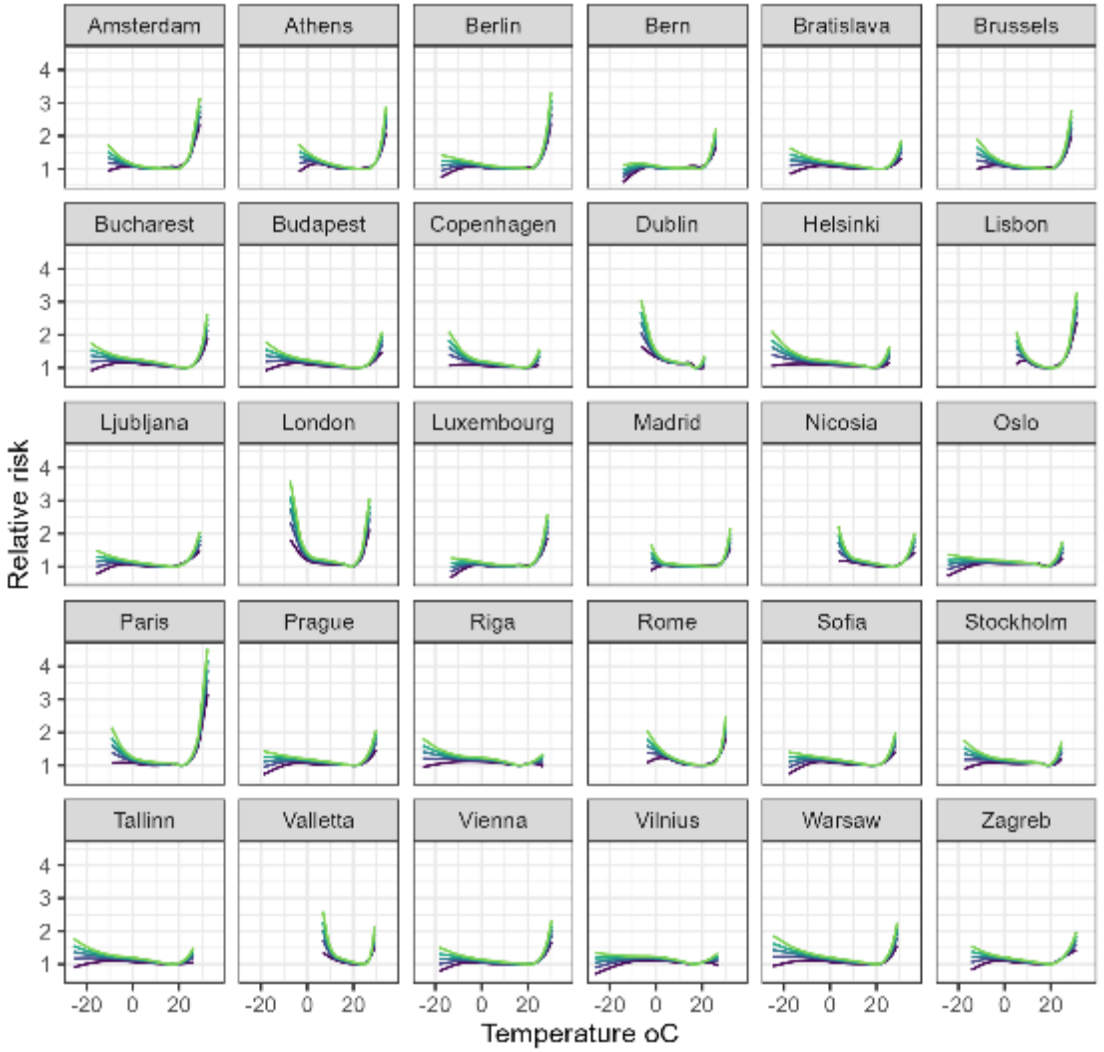
854 cities in Europe

London School of Hygiene and Tropical Medicine

Excess mortality attributed to heat and cold: a health impact assessment study in 854 cities in Europe

Pierre Masselot, PhD [a] · Malcolm Mistry, PhD [a,d] · Jacopo Vanoli, MSc [a] · Rochelle Schneider, PhD [a,b,e]
Tamara Iungman, MSc [f,g] · David Garcia-Leon, PhD [h] · et al. Show more





Counterfactuals
World Weather Attribution

World Weather Attribution

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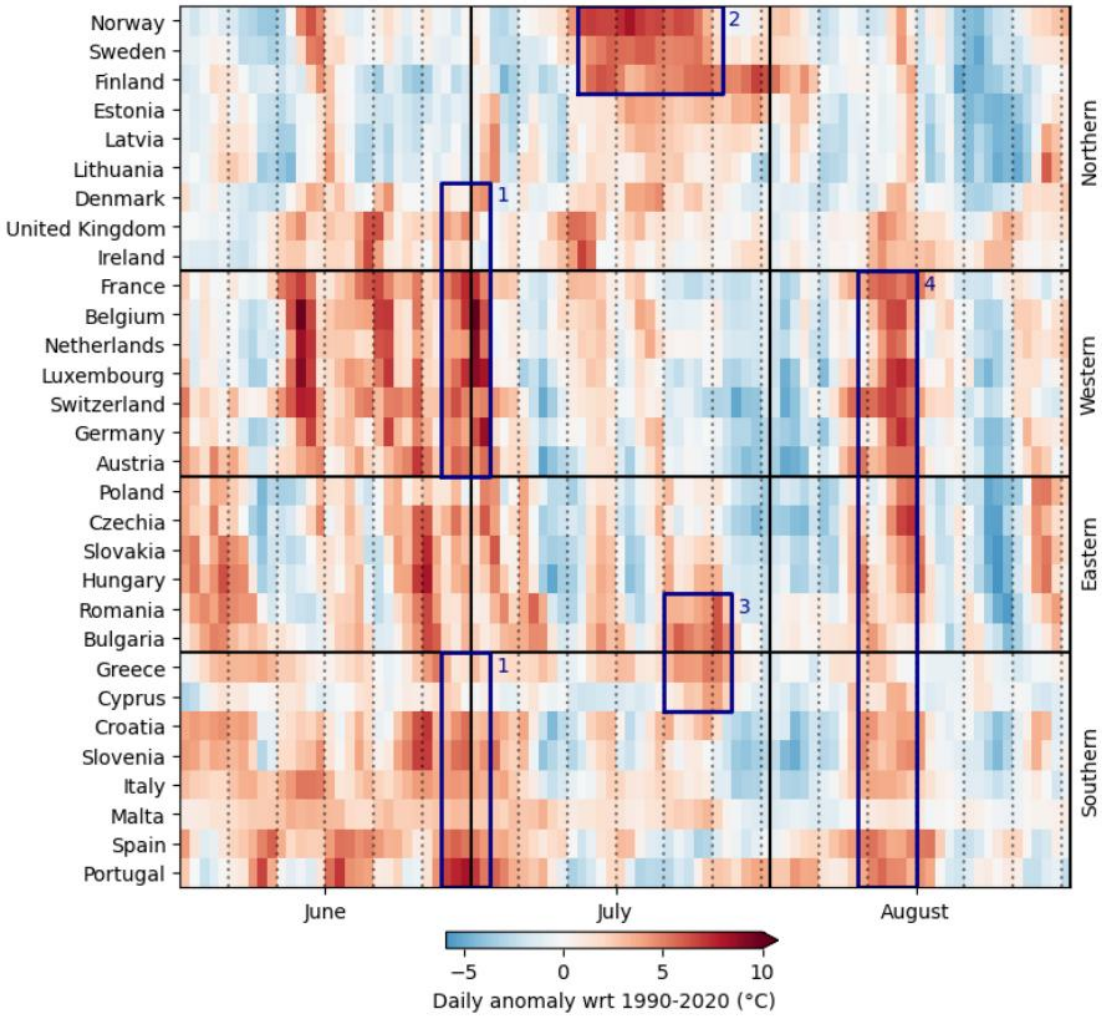
Extreme fire weather conditions in Spain and Portugal now common due to climate change

Heatwave

Heatwaves can be particularly dangerous to humans, and occur all over the world with increasing intensity.

Extreme rainfall

Rainfall events from a major storm or hurricane, or intense localised downpours can lead to flooding in any type of location.



Outreach

Grantham Institute – Climate Change and the Environment

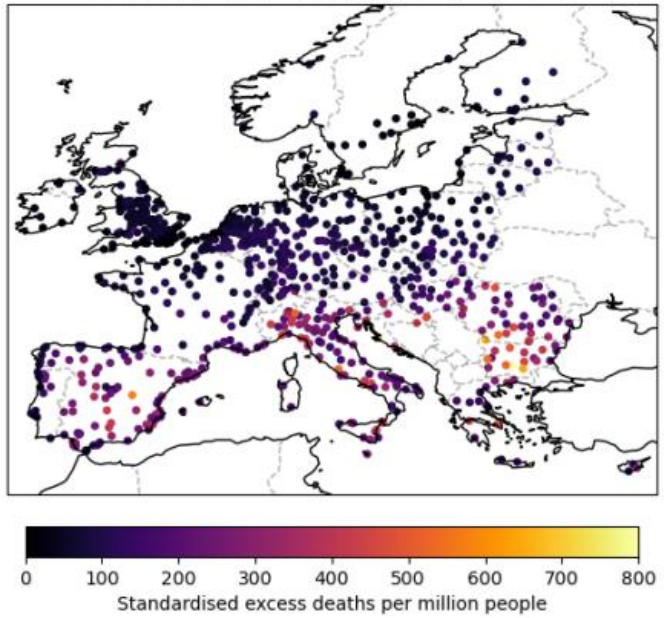
Grantham comms team pipeline

1. Identify the event of interest.
2. Discuss if this event complies with guidelines (is there interest? Are there previous studies?)
3. Heads up to different networks (e.g., Global strategic communications council, climate journalists).
4. Write a press release and circulate 2-3 days before we publish it.
5. Hold a press briefing with the journalists.
6. Graphics for the study (infographics, videos, etc.)
7. Advertise on social media and website.
8. Respond to journalists and allocate speakers/interviewees.
9. Media training to academics

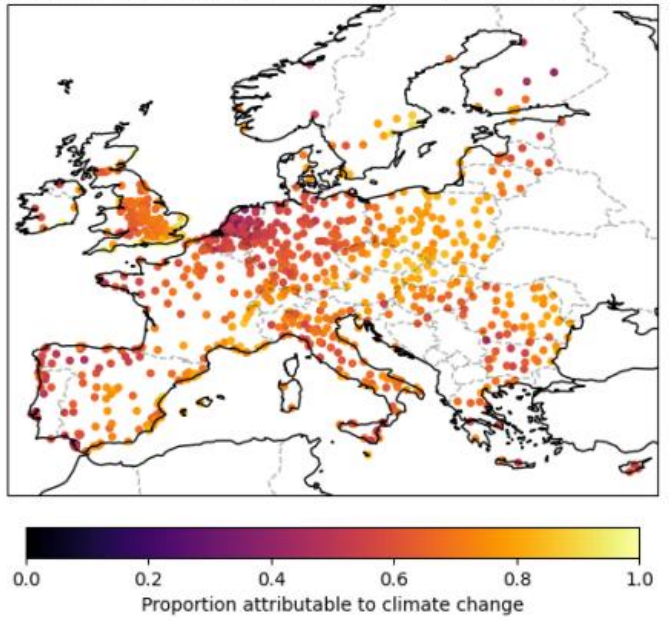
Results

Age group	Population	Excess deaths	Rate per 1 million population	Attributable to climate change	Proportion of excess deaths due to climate change
Total	158,473,649	24404 (21968, 26806)	154 (139, 169)	16496 (15013, 17864)	0.68 (0.64, 0.71)
20-44	66,886,597	608 (434, 795)	9 (6, 12)	279 (208, 352)	0.46 (0.36, 0.57)
45-64	54,059,644	3058 (2557, 3593)	57 (47, 66)	1866 (1589, 2133)	0.61 (0.55, 0.67)
65-74	19,676,737	3738 (3279, 4171)	190 (167, 212)	2487 (2210, 2738)	0.67 (0.63, 0.7)
75-84	12,762,858	7019 (6305, 7726)	550 (494, 605)	4835 (4408, 5250)	0.69 (0.66, 0.72)
85+	5,087,812	9959 (9012, 10964)	1957 (1771, 2155)	7028 (6397, 7657)	0.71 (0.67, 0.73)

(a) Standardised excess deaths due to heat



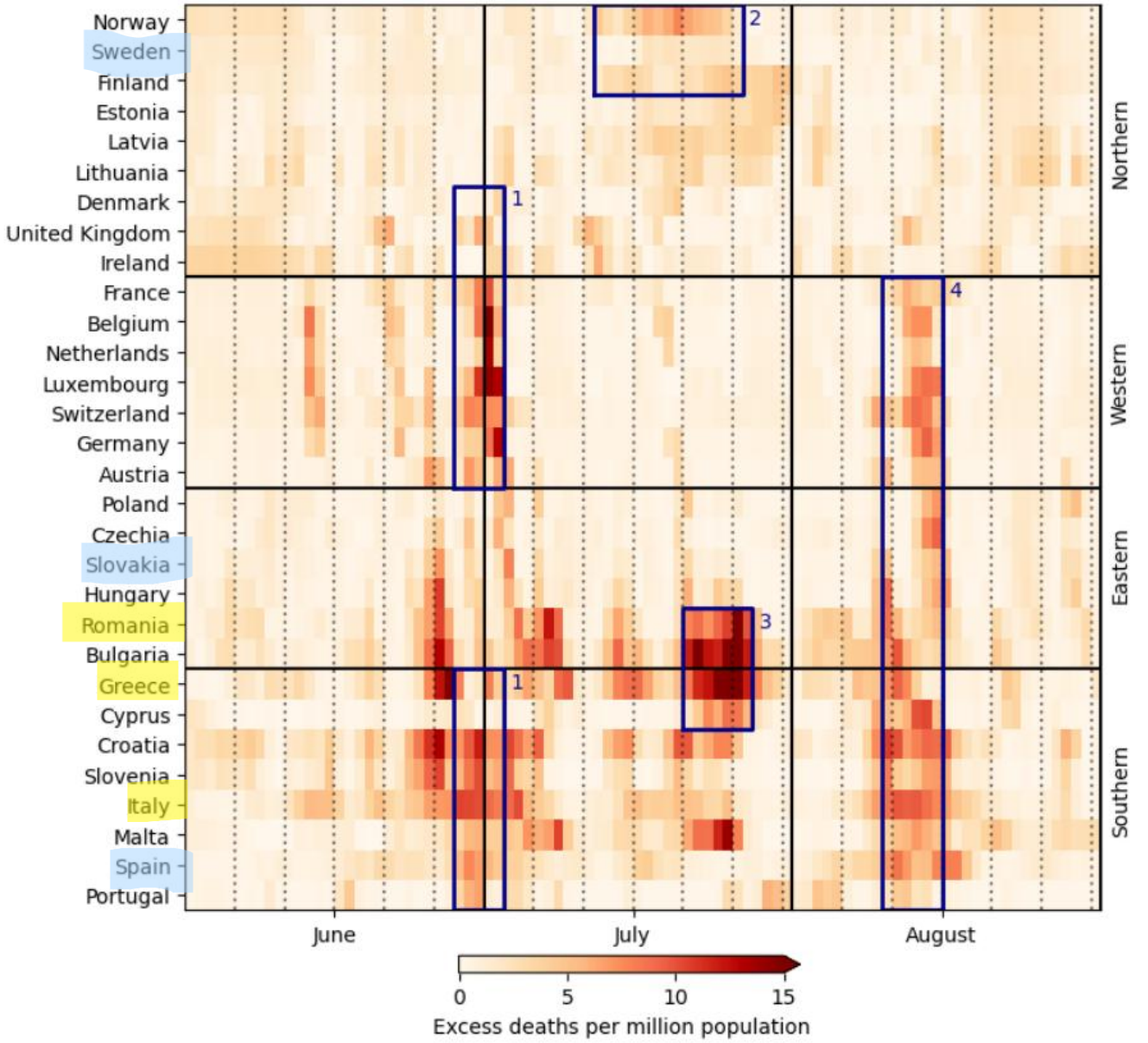
(b) Proportion of excess deaths attributable to climate change



Results

Among 30 European capitals:

- Rome, Athens, and Bucharest had the highest estimated excess mortality per population this summer.
- Rome: 1280 (1135, 1432),
- Athens: 1093 (905, 1274) and
- Bucharest: 472 (359, 609)
- The largest relative proportions in Stockholm, Madrid, and Bratislava, with more than 85% deaths to be attributed to climate change.



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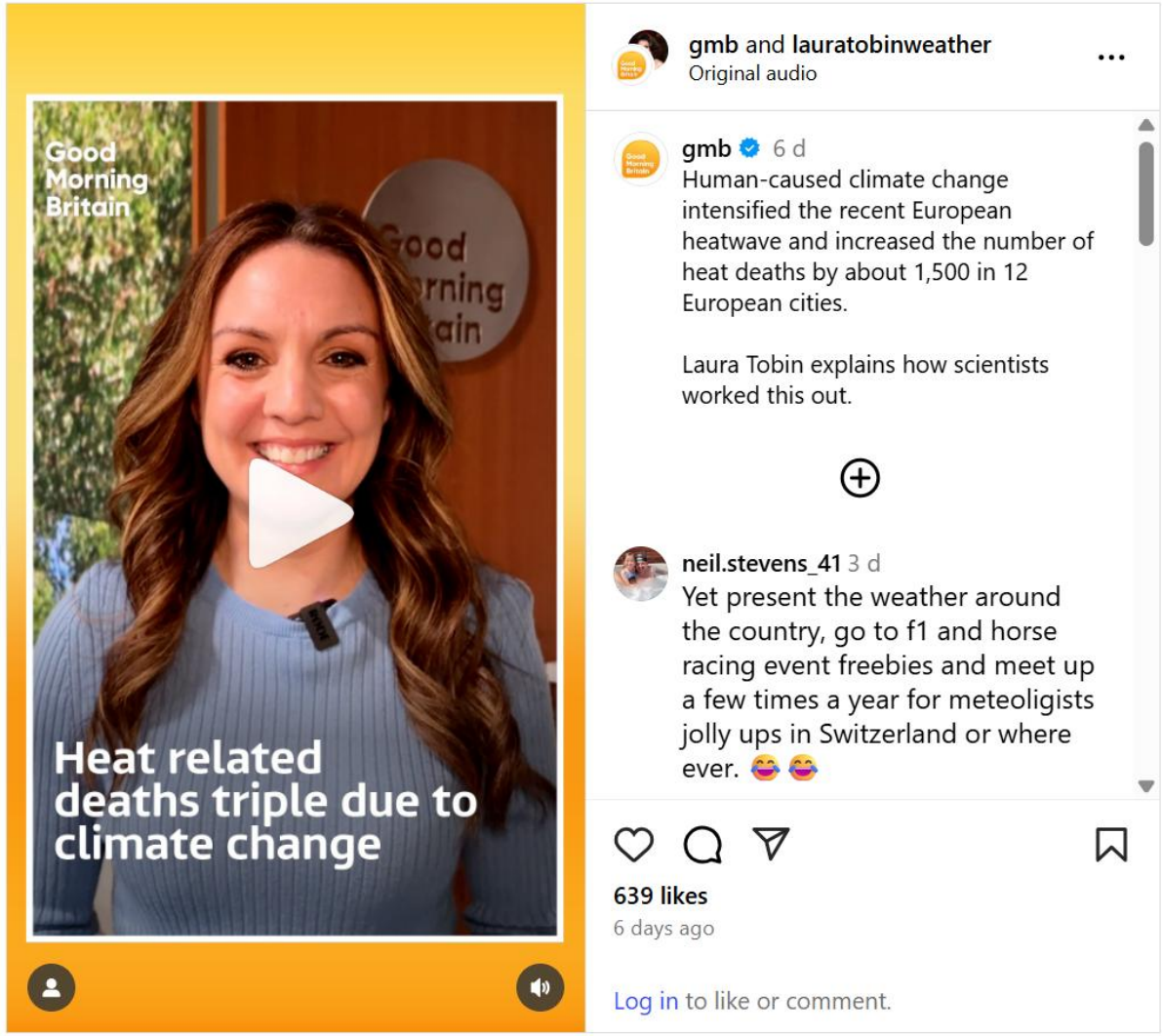
Climate Change Led to At Least 16,500 Heat Deaths in Europe This Summer



Conclusions

Wrapping things up

- Heatwaves are silent killers
- Almost 70% of the heat-related deaths are attributed to human induced climate change
- Heat and climate has disproportionately affected different European cities
- Rapid health studies are very useful to raise awareness and protect the vulnerable.

Implications

- Adaptation plays a key role, yet its gains may be offset by the continued increase in temperatures
- Current policies in place around the world are projected to result in about 2.7°C of warming above pre-industrial levels by 2100, which would result in many more heat-related deaths and impacts globally.
- We need to rapidly transition away from fossil fuels to secure a liveable future.

If the world hasn’t heard the message, it’s because we haven’t spoken loudly enough. Let’s change that.









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Thank you

30/09/2025